Design and Analysis of Bamboo as a Reinforcing Material

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***Abstract*— The extensive usage of bamboo in place of steel as a reinforcing material in concrete construction as well as its application in load-bearing concrete members. The document has been developed using the findings and conclusions from earlier reports on a number of experiments that were carried out to ascertain bamboo's mechanical qualities and its suitability as a building material. The use of bamboo in place of steel as a whole as well as with steel is shown to ensure the reduction in weight, economic advantages with its strength compromised to a slight and safe level, and the design principles involved in creating bamboo reinforced members and structures. The results of several studies and research projects will be used to identify the optimum procedure for using bamboo as a substitute for steel or other reinforcing materials in the proper quantity, proportion, and location. The report must demonstrate a technique that does not jeopardize the structure's safety.**

***Index Terms*—Staad Pro connect edition, Ms Excel.**

I. INTRODUCTION

In this research, the examination into the use of bamboo as a supplementary material to steel in RCC building has been demonstrated with the affordability, safety, convenience, and durability of the specific application. Despite its wealth of characteristics, strength, and cost-effective benefits, bamboo has been used less and less as a building material in modern times since it was first used for homes. The methods are offered by members of the group for greater efficacy and greater strength with the fewest strength compromises. The designs offered are those that have been tested on software simulation for safe working load and failure analysis, but the methods proposed in this study are not guaranteed to have the best results or with any assurance of the maximum strength of a structure. If techniques like these are used widely and studies for the development of a code pertaining to concrete design with bamboo reinforcements can be brought forward for a better future of economical and eco-friendly RCC construct, it could be very beneficial and have a very good breakthrough in the field of designing concrete with prominent economical benefits over steel (being used with it) and its benefits related to the reduction of carbon emission in the atmosphere.

II. METHODOLOGY

Planning is essential for the successful completion of any project, hence it is essential to do so both before the project begins and throughout its execution.

In this project, we designed a 1-foot-deep column for concrete reinforcement utilizing bamboo culms rather than steel bars. To confirm the column's viability, we tested the column's tensile strength using a variety of tools such the CTM and UTM.

Using the planning and modeling program STAAD PRO, we are also creating a G+2 structure where bamboo is employed as concrete reinforcement. After that, we will compare it to a G+2 structure where standard steel bars are utilized. Design principal and calculation done for bamboo reinforcement are taken from US NAVAL CORPS guidelines and references.

Bamboo Characteristics

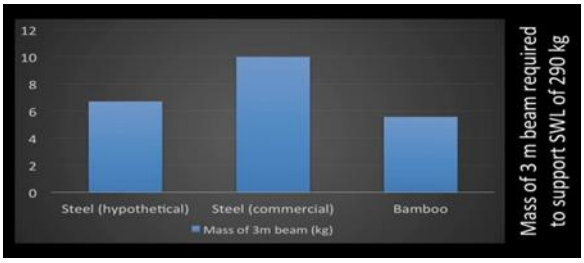
Construction of bamboo-reinforced concrete uses the same design, mix ratio, and construction methods as steel-reinforced concrete. Bamboo reinforcement shares many of the same characteristics as steel reinforcement. Bamboo has been employed in various building construction projects, including scaffolding work, formwork support stands, and more. These are only available for medium-sized papers. Because it is natural and environmentally friendly, it is energy efficient.

Some specific properties of bamboo:

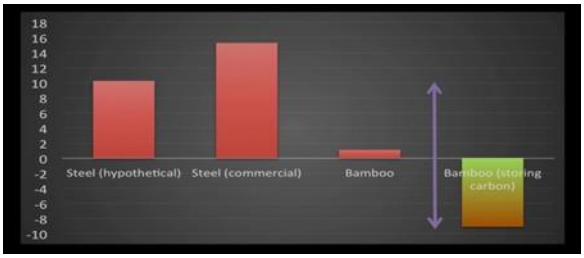
Specific gravity – 0.575 to 0.655

Average weight – 0.625 kg/m
Modulus of elasticity – 1.5 to 2.0 x 105 kg/cm2 Ultimate compressive stress – 794 to 894 kg/cm2 Safe working stress in compression – 105 kg/ cm2 Safe working stress in tension – 160 to 350 kg/ cm2 Safe working stress in shear – 115 to 180 kg/cm2 Bond stress – 5.6 kg/cm2

Bamboo and steel weight comparison



- Major Benefits of Bamboo over steel



IV. UNITS

Carbon emission by steel and bamboo

Mechanical properties of bamboo

Mechanical property	Symbol	Value [N/mm²]
Ultimate compressive strength		55.15806
Allowable compressive stress	Σ(c)	27.57
Ultimate tensile strength		124.1
Allowable tensile stress	Σ	27.57
Allowable bond stress	U	0.3447
Modulus of elasticity	E	1.7x10^4

When planning the design of columns and beams, whether using only bamboo reinforcements or replacing them with steel, these attributes have been taken into consideration. The only disadvantage of STAAD.PRO software is that it will not take into account the shape and section of the bamboo` and will, at most, be implemented on Stand.Pro. A different approach would be to combine the yield stress, tensile strength, and compressive strength of bamboo with steel before developing using traditional techniques. Theoretically, both techniques will be verified.

II TEST RESULTS

The ultimate compressive strength test-

a) Take a bamboo specimen from a full grown bamboo of pronounced brown color
b) Make sure that the bamboo is properly seasoned and shows a brown color, bamboo showing green color should be avoided.
c) The bamboo specimen was cut 160 mm long and had a thickness of 10mm with the outer radius of 560 mm and inner radius of 540 mm.
d) The specimen was then put in the CTM and uniform pressure of 10 KN/sec was applied axially.
e) The bamboo failed on 100 KN of max. Axial load.

Compressive strength test of the bamboo specimen in

CTM

Compressive test results (bamboo)

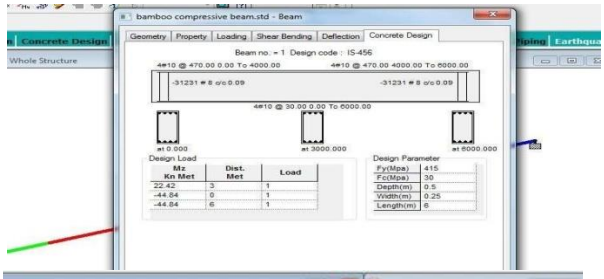
Ultimate Compressive strength (MPa)	55.3
Ultimate tensile strength (MPa)	224.3
Modulus of Rupture (MPa)	122.9
Modulus of Elasticity (MPa)	20.8 x 10^3

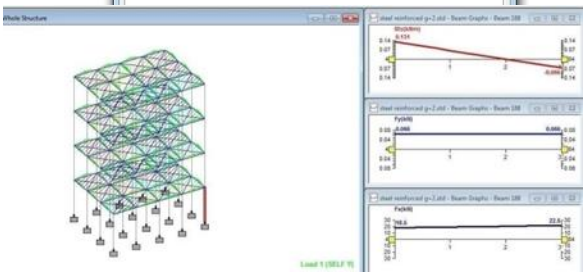
The ultimate tensile strength test-The test was carried out on a UTM and the test of tension strength till failure was conducted. Dimensions: Length data: Le = 205mm; Lc = 205mm Test Rates: V0 = 30mm/min; V1 = 6MPa/s Rate switch points: F0 = 10kN

End of test criterions: Force = 1000kN; dF = 50%
Bamboo will be tested for sections of different dimensions i.e. 10x10, 12x10, 16x10, 20x10, 25x10. All the tests that were conducted have been followed as they have been presented in the research papers mentioned before. Following are the results of steel an

IV STAAD.PRO RESULTS

All the results obtained by the tests and simulations under different conditions which were applied on STAAD.PRO for the design of the whole structure reinforced with bamboo and steel together will be shown in this article. The members that were tested beforehand and the members substituted in the structure will also be elaborated for their design results and their respective properties assigned. All the loads that have been put on the structure and the individual members which are responsible for the displacements, bending moments and shear reactions have all data available . Now the results for the individual members and the steel reinforced and the steel and bamboo coupled structures would be depicted. Results for the steel and bamboo coupled reinforced concrete beam is shown as follows





V-ESTIMATION

In this project, a G+2 building has been created in two different ways. In the first instance, steel was utilized as reinforcement in both compression and tension; in the second, steel was employed in tension and a combination of steel and bamboo in compression. STAAD.PRO, a program for creating and modeling, is the subject of the analysis. The advantages of utilizing bamboo with steel as a reinforcing material in building have been demonstrated using a rough estimate.

Estimate of the whole project (STAAD.PRO) In this project we are analyzing a G+2 building in two cases- In case-1 only steel has been used for reinforcement.

In case-2, combination of steel and bamboo has been used for reinforcement in compression.

Table: No. of beams and columns in the STAAD.PRO structure

Building case Design	No. of Beams	No. of columns
G+2 (steel in both tension and compression)	124	80
G+2 (steel in tension and combination of steel and bamboo in compression)	124	80

Structure 1- (Steel as reinforcement in both tension side & compression side)

Particulars	In Tension Side	In Compression Side
No. of Steel bars in bean	300	240
No. of Steel barsin column	200	160

S.NO	BAR DIA. (in mm)	WEIGHT (kg)	COST (₹/kg)	TOTAL COST (₹)
1.	6	333	70	23310
2.	8	299	72	21528
3.	10	765	70	53550
4.	12	854	69	58926
		OVERALL WEIGHT=2251		OVERALL COST = 157314

So the overall cost of reinforcement in this building design is ₹- 157500/-

Table : Structure 2-(Steel as reinforcement in tension side & combination of steel & bamboo in compression side)

Particulars	In Tension Side	In Compression Side Steel	In Compression Side Bamboo

No. of Bars in Beam	320	140	120
No. of Bars in Column	280	120	100

So the overall cost of reinforcement in this building design is ₹- 101000 (approx.) If the method shown in case 2 cannot be relied upon another method can be used in which, 50% of the steel in compressive zone of the structure can be replaced with bamboo. Assuming that in the steel reinforced structure, the 6mm and 8mm bars are used in compression, half their weight will be replaced by weight of bamboo and then a direct deduction of cost will be shown.10 mm thick culms can be used, but no restrictions are there for the use *of thicker culms.*

THE ECONOMICAL COUNTERPART

In this project, a G+2 building has been created in two different ways. In the first instance, steel was utilized as reinforcement in both compression and tension; in the second, steel was employed in tension and a combination of steel and bamboo in compression. STAAD.PRO, a program for creating and modeling, is the subject of the analysis. The advantages of utilizing bamboo with steel as a reinforcing material in building have been demonstrated using a rough estimate.

S.N	Reinforcing Material	BAR DIA. (in mm)	WEIGHT(kg)	COST(₹/kg)	TOTAL COST (₹)
1.	In tension side (only Steel)	8	535	72	38520
2.	In tension side (only Steel)	10	400	70	28000
3.	In Compression side (Bamboo + Steel)	Steel- 8 Bamboo- 20	Steel –200 Bamboo- 400	Steel- 72 Bamboo- 50(estimated)	Steel-14400 Bamboo-20000
			OVERALL WEIGHT = 1535		OVERALL COST = 100920

VI-CONCLUSION

Bamboo was chosen as the material for supporting beams and columns because of this quality. This project report has concentrated on providing a method by which steel and bamboo can be used together so that the strength of the member and thus the structure is not compromised with sighting a reduction in self-weight and making the structure economical. It is a certainty that the structural member that has been reinforced with bamboo will lose its strength up to a significant limit. STAAD.PRO has been utilized in this report as the simulator, confirming that the structure can be safe and that all of its members would pass with a modification in the material used for reinforcement. Therefore, it has been determined that bamboo can be used to reinforce a structure in the areas where compression needs to be addressed. Wherever necessary, steel and bamboo will be combined, and no more than 25% of the steel in a member and no more than 40% of the steel in the entire structure should be replaced. Bamboo can only be utilized in constructions as reinforcement The G+2 structure, which was employed to verify the validity of the structure's strength with the modified reinforcement properties, can be applied conventionally to real-world structures, or a structure that was fully reinforced with steel can be reinforced with bamboo, with the diameters of the bars in those zones increased to maintain the strength factor. When the structure with the altered characteristics was reinforced with bamboo on paper, a weight decrease of 716 kg was seen. While the structure strengthened with bamboo and steel cost Rs. 101000 for the reinforcement, the structure reinforced totally with steel required an estimated total of Rs. 157500.

Therefore, it can be stated that the method provided in this study has structural applications better than the conventional ones and may be used for all elements of civil engineering on an advantageous note, including economics, safety, and environmentally friendly construction. This study can also be utilized to improve the statistics for the creation of a code that would reinforce typical concrete buildings with steel and bamboo.

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